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# Analysis of the supply chain coordination potential of different contracts under random production yield

(Analyse der Koordinationsfähigkeit verschiedener Kontrakte bei unsicherer Produktionsausbeute)

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- **Motivation**
- **Supply chain (SC) model and yield uncertainty**
- **Analysis of coordination potential of different contract types**
- **Conclusion and further research**

## ➤ Coordination in SC management

- *Avoiding efficiency losses*
- *Contracts as monetary incentive for coordinating behavior*

## ➤ Uncertainty in SC coordination context

- *Demand uncertainty at retailer stage*
- *Uncertainty w.r.t. production yield at supplier (material or process risks)*
  
- *In literature*
  - ⇒ Demand uncertainty and contracting well-studied
  - ⇒ Few contributions (<10) on contracting under supply uncertainty
    - Published in leading journals (EJOR, IJPE)
    - Majority published after 2007
  
- *Contracts proposed for coordination under stochastic yield*
  - ⇒ Wholesale price (WP) contract usually does not coordinate
  - ⇒ More complicated contracts necessary (penalty, buy back, revenue sharing)

## ➤ Categorization of literature on coordination under random yield

SC type and demand		SC type	
		<i>serial</i>	<i>converging</i>
Demand	<i>deterministic</i>	Inderfurth/Clemens (2011)	Gurnani/Gerchak (2007) Yan u.a. (2010)
	<i>stochastic</i>	He/Zhang (2008) Xu (2010) He/Zhao (2011) Inderfurth/Clemens (2011)	Guler/Bilgic (2009)

- **Research objective**

⇒ Analyzing specific contract types under various supply chain settings w.r.t. their coordination potential

## ➤ Assumptions

- **Multiple decision makers and action fields**
  - ⇒ Buyer (B): Order quantity ( $Y$ )
  - ⇒ Supplier (S): Production quantity, emergency production quantity ( $Q, M$ )
- **Production yield is uncertain (stochastically proportional)**
- **Two alternatives for dealing with shortages (with/without emergency option)**
- **Two alternatives for final demand (deterministic/stochastic) ( $D, X$ )**
- **Modelling as Stackelberg game (B is leader, S is follower)**



Demand

$D, X$

Costs/prices

$c$

$w$

$p$

Yield rate

$z$  with distribution  $\Phi(z)$  and  $0 \leq z \leq 1$

Decisions

$Q, M$

$Y$

Production output

$z \cdot Q$

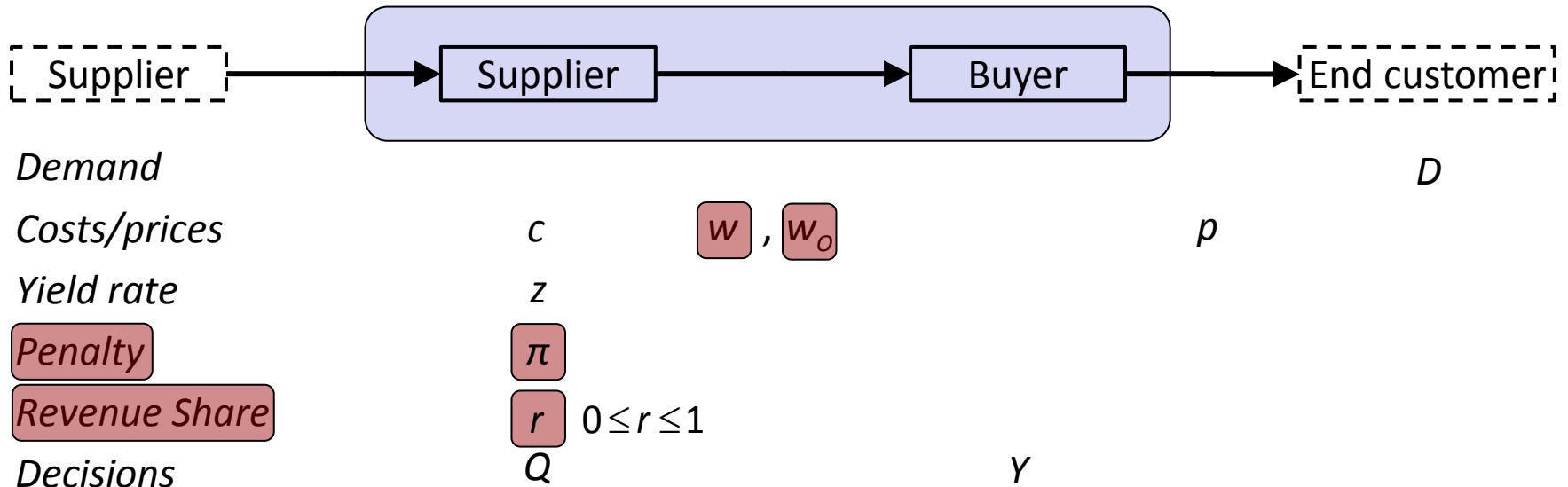
➤ **Four different scenarios**

<b>1</b> <i>Deterministic demand</i> <b>without emergency source</b>	<b>2</b> <i>Stochastic demand</i> <b>without emergency source</b>
<b>3</b> <i>Deterministic demand</i> <b>with emergency source</b>	<b>4</b> <i>Stochastic demand</i> <b>with emergency source</b>

- ***Emergency source is not subject to uncertainty***

➤ Scenario 1

Scenarios		Demand occurrence	
		<i>deterministic</i>	<i>stochastic</i>
Emergency production source	<i>not available</i>	<ul style="list-style-type: none"> <li>▶ Wholesale Price Contract [<b>WPC</b>]</li> <li>▶ Overproduction Risk Sharing Contract [<b>ORS</b>]</li> <li>▶ Penalty Contract [<b>PEN</b>]</li> <li>▶ Revenue Sharing Contract [<b>RS</b>]</li> </ul>	...
	<i>available</i>	...	...



## ➤ WPC (Wholesale Price Contract)

- *Only wholesale price  $w$  is paid to supplier*

## ➤ ORS (Overproduction Risk Sharing Contract)

- *Actors share the risk of overproduction (B takes excess units from S at lower price  $w_o$ )*

## ➤ PEN (Penalty Contract)

- *Supplier pays a per unit penalty  $\pi$  to buyer in case of underdelivery*

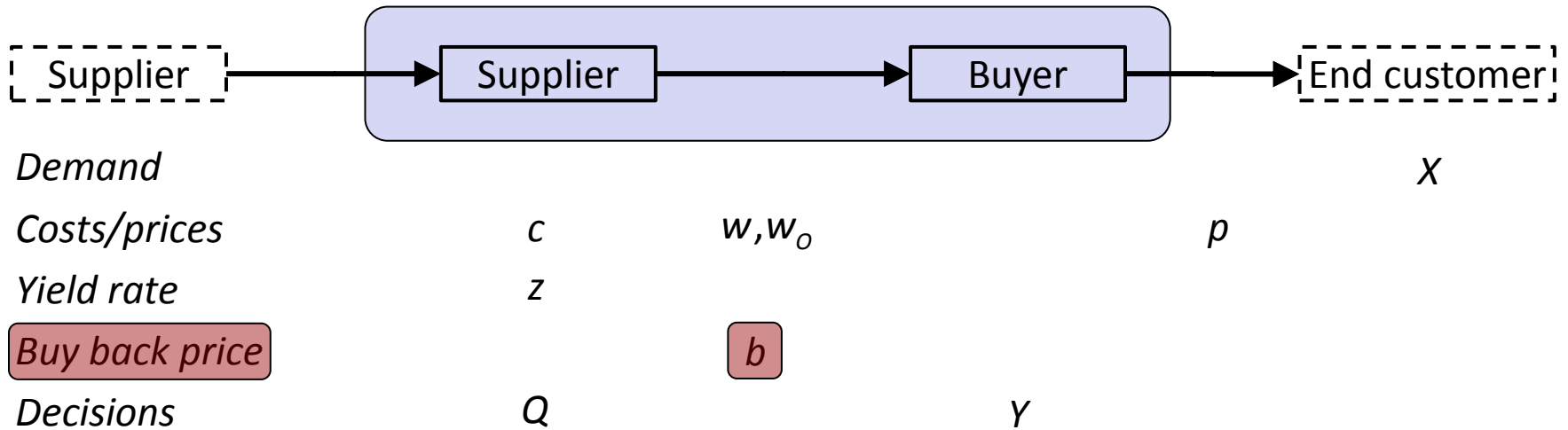
## ➤ RS (Revenue Sharing Contract)

- *Buyer shares portion  $r$  of the sales revenue with supplier*



## ➤ Scenario 2

Scenarios		Demand occurrence	
		<i>deterministic</i>	<i>stochastic</i>
Emergency production source	<i>not available</i>	...	<ul style="list-style-type: none"> <li>▶ Wholesale Price Contract [<b>WPC</b>]</li> <li>▶ Overproduction Risk Sharing contract [<b>ORS</b>]</li> <li>▶ Penalty Contract [<b>PEN</b>]</li> <li>▶ Buy Back Contract [<b>BB</b>]</li> <li>▶ Revenue Sharing Contract [<b>RS</b>]</li> </ul>
	<i>available</i>	...	...

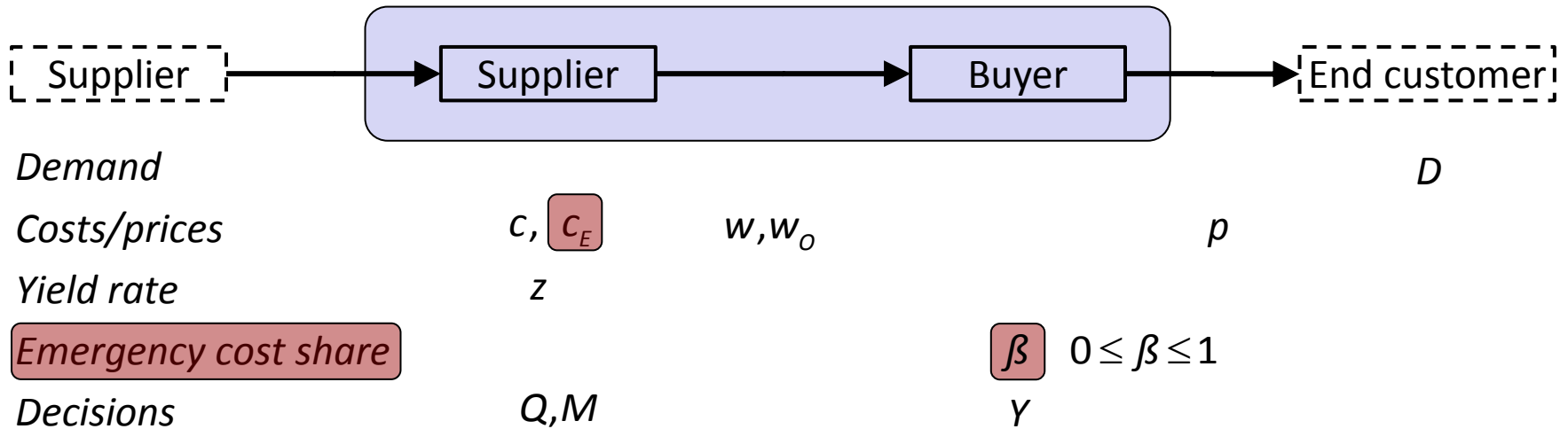


## ➤ BB (Buy Back Contract)

- *Supplier buys back excess units from buyer at end of period at unit price  $b$*

## ➤ Scenario 3

Scenarios		Demand occurrence	
		<i>deterministic</i>	<i>stochastic</i>
Emergency production source	<i>not available</i>	...	...
	<i>available</i>	<ul style="list-style-type: none"> <li>▶ Wholesale Price Contract [WPC]</li> <li>▶ Overproduction Risk Sharing Contract [ORS]</li> <li>▶ Underproduction Risk Sharing Contract [URS]</li> <li>▶ Revenue Sharing Contract [RS]</li> </ul>	...



## ➤ URS (Underproduction Risk Sharing Contract)

- **Actors share the risk of underproduction**  
 ⇒ Buyer bears portion  $\beta$  of emergency production cost  $c_E$

➤ Scenario 4

Scenarios		Demand occurrence	
		<i>deterministic</i>	<i>stochastic</i>
Emergency production source	<i>not available</i>	...	...
	<i>available</i>	...	<ul style="list-style-type: none"> <li>▶ Wholesale Price Contract [<b>WPC</b>]</li> <li>▶ Overproduction Risk Sharing Contract [<b>ORS</b>]</li> <li>▶ Underproduction Risk Sharing Contract [<b>URS</b>]</li> <li>▶ Buy Back Contract [<b>BB</b>]</li> <li>▶ Revenue Sharing Contract [<b>RS</b>]</li> </ul>



<i>Demand</i>					$X$
<i>Costs/prices</i>	$c, c_E$	$w, w_o, b$		$p$	
<i>Yield rate</i>	$z$				
<i>[various]</i>	$\pi, r$		$\beta$		
<i>Decisions</i>	$Q, M$		$Y$		

➤ **No news**

➤ **But: Are mixed versions possible?**

## ➤ Currents results

(+) → coordination achieved

(-) → coordination not achieved

(?) → to be studied

Scenarios	without emergency source		with emergency source	
	<i>deterministic demand</i>	<i>stochastic demand</i>	<i>deterministic demand</i>	<i>stochastic demand</i>
<b>WPC</b>	(-)	(-)	(+)	(-)
<b>ORS</b>	(?)	(?)	(?)	(?)
<b>URS</b>			(-)	(-)
<b>PEN</b>	(?)	(?)		
<b>BB</b>		(?)		(?)
<b>RS</b>	(?)	(?)	(?)	(?)

## ➤ Conclusion

- ***Increasing interest in topic***
- ***Already known contracts have potential to coordinate SCs***
  - ⇒ WPC can coordinate under certain circumstances
  - ⇒ From numerical analysis of URS and ORS
    - URS fails to coordinate the SC in each case
    - ORS has potential to achieve coordination

## ➤ Outlook

- ***Analytical/numerical proof of all contracts' ability/disability to coordinate***
- ***Find further contract types (new or mixed types)***
- ***Different (more complex) SC environments***
- ***Different yield distribution: binomial yield***
- ***Experimental testing (?)***



# Thank you for your attention!

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- **Guler M.G., Bilgic T.** (2009) On coordinating an assembly system under random yield and random demand. EJOR: 196(1) 342-350.
- **Gurnani H., Gerchak Y.** (2007) Coordination in decentralized assembly systems with uncertain component yields. EJOR: 176(3) 1559-1576.
- **He, Yo., Zhao, X.** (2011) Coordination in multi-echelon supply chain under supply and demand uncertainty. IJPE: in press.
- **He, Yu., Zhang, J.** (2008) Random yield risk sharing in a two-level supply chain. IJPR: 112(2) 769-781.
- **Xu, H.** (2010) Managing production and procurement through option contracts in supply chains with random yield. IJPE: 126(2) 306-313.
- **Yan X., Zhang M., Liu K.** (2010) A note on coordination in decentralized assembly systems with uncertain component yields. EJOR: 205(2) 469-478.